LONDON-WEST MIDLANDS ENVIRONMENTAL STATEMENT

Volume 5 | Technical Appendices

CFA21 | Drayton Bassett, Hints and Weeford

Flood risk assessment (WR-003-021)

Water resources

November 2013

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Department for Transport

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Appendix WR-003-021

Environmental topic:	Water resources and flood risk assessment	WR
Appendix name:	Flood risk assessment	003
Community forum area:	Drayton Bassett, Hints and Weeford	021

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1 Introduction

1.1 Structure of the water resources and flood risk assessment appendices

1.1.1 The water resources and flood risk assessment appendices comprise of four parts. The first of these is a route-wide appendix (Appendix WR-001-000).

1.1.2 Three specific appendices for each community forum area (CFA) are also provided. For the Drayton Bassett, Hints and Weeford area (CFA21) these are:

- a water resources assessment (Appendix WR-002-021);
- a flood risk assessment (FRA) i.e. this appendix; and
- a river modelling report (Appendix WR-004-014)

1.1.3 Maps referred to throughout the water resources and FRA appendices are contained in the Volume 5 water resources map book.

1.2 Scope of this assessment

1.2.1 This FRA considers the assessment of flood risk in this study area, which is defined as the area within 1km of the route centre line within CFA21. The assessment has been carried out in accordance with the requirements of the National Planning Policy Framework (NPPF)[1], which aims to prevent inappropriate development in areas at risk of flooding and to ensure that, where development is necessary in areas at risk of flooding, it is safe without increasing flood risk elsewhere.

1.2.2 This FRA presents baseline (current day) flood risk and post-construction flood risk as a result of the Proposed Scheme and has been written to demonstrate the relative change in flood risk as a result of the Proposed Scheme. Whilst all change in risk status is highlighted, the focus of the document is on the change in risk status to local receptors, particularly existing infrastructure.

1.2.3 A risk-based methodology has been adopted through the application of the source-pathway-receptor model. This model has been used to identify the cause of 'sources' of flooding to and from a development. The identification is based on a review of local conditions and consideration of the effects of climate change.

1.2.4 In order for there to be a flood risk, all the elements of the model (a flood source, a pathway and a receptor) must be present. Furthermore, effective mitigation can be provided by removing one element of the model, for example by removing the pathway or receptor.

1.2.5 Receptors may include people and their properties, business and infrastructure, and the built and natural environment within the range of the flood source which are connected to the source of flooding by a pathway.

[1] Department for Communities and Local Government (2012), *National Planning Policy Framework.*

1.2.6 This FRA has been completed to inform the Environmental Statement (ES) for the works, which will be a key part of the HS2 hybrid Bill submission required for the Proposed Scheme. The hybrid Bill is necessary for powers to build the railway, powers to buy land and for planning consent.

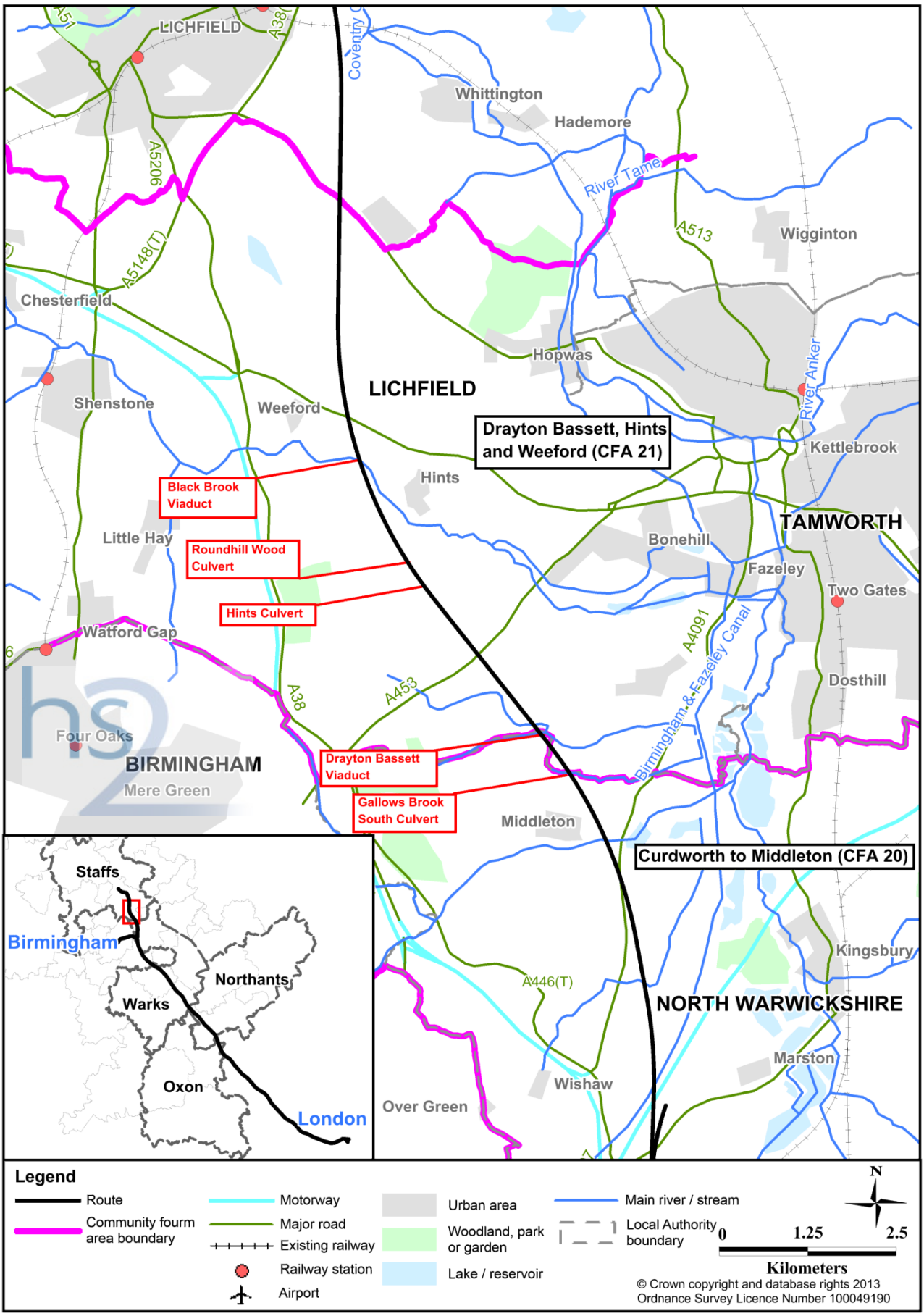
1.2.7 The Proposed Scheme will cross numerous surface water features within this study area, which are Black Brook, two other tributaries of Bourne Brook, two tributaries of the River Tame and Gallows Brook along the southern boundary of this study area.

1.3 Location

1.3.1 In this FRA the study area covers a 9.1km section of the Proposed Scheme in the District of Lichfield, Staffordshire, where it passes through the countryside between Sutton Coldfield and Tamworth. The City of Lichfield is situated to the north-west of the area. The study area follows the route from the county boundary between Warwickshire and Staffordshire in the south to its crossing of the A51 Tamworth Road at Whittington Heath in the north and includes land within the communities of Drayton Bassett, Hints, Canwell, Weeford, Swinfen and Packington.

1.3.2 A location plan of the Proposed Scheme within this study area is shown on Figure 1.

Figure 1: Location plan



2 Flood risk assessment methodology

2.1 Source-pathway-receptor model

2.1.1 Flood risk is assessed using the source-pathway-receptor model. In this model, individual sources of flooding within the study area are identified. The primary source of flooding is rainfall, which is a direct source in the short term (surface water flooding) and can lead to flooding from watercourses (river flooding) and overloaded man-made collection systems (sewers) in the short or medium term. Stored rainfall, either naturally in aquifers (groundwater) and natural lakes or artificially impounded reservoirs and canals can lead to flooding when the storage capacity of the system is exceeded.

2.1.2 A final source of flooding arises from tidal effects and storm surges caused by low pressure systems over the sea. However given the inland location of this study area, this final source of flooding does not pose a risk.

2.1.3 For there to be a risk of flooding at an individual receptor there must be a pathway linking it to the source of flooding. The pathways within the study area are assessed by reviewing national datasets that show the spatial distribution of flood risk. The associated risk magnitude is then categorised.

2.1.4 In general, receptors considered in this assessment include the Proposed Scheme and existing development within 1km of the route centre line. However any receptors beyond this, where a significant impact was expected, were considered in this assessment. The Proposed Scheme includes all associated temporary and permanent infrastructure. Areas of interest are identified through comparison of the national spatial datasets with the design drawings. Where a risk is identified, mitigation is required as part of the design to prevent an increase in flood risk in line with recommendations in the NPPF.

2.1.5 The vulnerability of each receptor is classified using Table 2 of the NPPF Technical Guidance Document[2].

2.1.6 The assessment then considers the vulnerability of the receptor with reference to the flood risk category of the source using Table 3 of the NPPF Technical Guidance Document and assesses whether the scheme has any potential to influence or alter the risk of flooding to each receptor. The Proposed Scheme will ensure that there is no adverse effect on the risk of flooding to third party receptors, and therefore, where such potential exists, mitigation is proposed based on further analysis.

2.1.7 The FRA defines the baseline flood risk and vulnerability of receptors. This is used to define the value, importance and significance of effects which is provided within the ES.

[2] Department for Communities and Local Government (2012), *National Planning Policy Framework Technical Guidance*.

2.2 Flood risk categories

2.2.1 The level of flood risk is categorised by assessing the design elements against the datasets for each source. A matrix showing the flood risk category associated with each flooding source is presented in Table 1.

Table 1: Flood risk category matrix for all flooding sources

Source of flooding	Flood risk category				
	No risk	**Low**	**Medium**	**High**	**Very high**
Watercourse[3]		Flood Zone 1	Flood Zone 2	Flood Zone 3a	Flood Zone 3b
Surface water / overland flow[4]	No FMfSW	FMfSW <0.3m for 1 in 200 year event	FMfSW >0.3m for 1 in 200 year event and FMfSW <0.3m for 1 in 30 year event	FMfSW >0.3m for 1 in 30 year event	
Groundwater[5]		Very low-low	Moderate	High-very high	
Drainage and sewer systems[6]	No sewer in vicinity of site	Surcharge point >20m from site and no pathways	Surcharge point within 20m of site and restricted pathways	Sewer network crosses site and pathways exist	
Artificial sources[7]	Outside of inundation mapping / no pathway exists	Within inundation mapping / pathway exists			

2.3 National planning policy framework

2.3.1 This assessment of flood risk makes use of the NPPF which is the Government's planning policy in relation to development and flood risk. It is set out within the NPPF that inappropriate development in areas at risk of flooding should be avoided by directing development away from areas at highest risk, but where development is necessary, making it safe without increasing flood risk elsewhere. The NPPF requires that proposed development located within Flood Zones 2 and 3 is assessed in relation to flood risk. This includes both flood risk to the development and any increases in flood risk elsewhere as a result of the development, with an allowance for climate change.

2.3.2 Methods used to ensure that development is at the lowest possible risk and that the development is safe without causing an increased risk elsewhere includes the application of the Sequential and Exception Tests. However, the Sequential Test has been considered as part of the overview FRA for the Proposed Scheme presented in Volume 3 of the ES.

[3] River flood risk taken from the Environment Agency Flood Zone mapping or hydraulic modelling carried for this FRA.
[4] Surface water flood risk taken from the Environment Agency Flood Maps for Surface Water (FMfSW).
[5] Groundwater flood risk taken from local flood risk assessment reports.
[6] Identified using Severn Trent Water's and South Staffs Water's assets network.
[7] Risk from reservoir flooding identified using the Environment Agency reservoir inundation mapping, canal flooding taken from identifying proximity of the Proposed Scheme to canals from Ordnance Survey mapping.

Flood zone classification

2.3.3 The NPPF splits the Environment Agency's Flood Map into three separate Flood Zones. These Flood Zones should be used in determining the appropriateness of proposed development uses and they represent flooding without flood defences in place.

2.3.4 The Flood Zones are defined as:

- Flood Zone 1 – Areas with a 'low probability' of flooding and where the annual probability of flooding is lower than 0.1% for either river or sea flooding. The NPPF imposes no constraints upon the type of development within Flood Zone 1;
- Flood Zone 2 – Areas with a 'medium probability' of flooding and where the annual probability of flooding is between 0.1 and 1.0% for river flooding or between 0.5 and 0.1% for sea flooding. The NPPF recommends that Flood Zone 2 is suitable for most types of development with the exception of 'highly vulnerable' land uses; and
- Flood Zone 3 – Areas with a 'high probability' of flooding and where the annual probability of flooding is 1.0% or greater for river flooding or 0.5% or greater for sea flooding. The NPPF recommends that appropriate development is based upon a further classification of Flood Zone 3: 3a high probability and 3b functional floodplain (where water has to flow or be stored in times of flood).

2.4 Local flooding planning policy documents

2.4.1 The local policies for this study area with implication in relation to flood risk are:

- Lichfield District Local Plan[8] – E15 Flood Protection. Policy E15 details that development in areas at risk of flooding will not generally be supported, unless suitable preventative measures are undertaken; and
- Lichfield District Local Plan: Our Strategy[9] – Core Policy 3: Delivering Sustainable Development. Core Policy 3 seeks to conserve water resources and promotes sustainable drainage techniques to manage run-off. The Policy also guides development away from areas at risk of flooding and requires site-specific flood risk assessments to be undertaken.

2.4.2 The Lichfield District Strategic Flood Risk Assessment (SFRA)[10] and the Staffordshire Preliminary Flood Risk Assessment (PFRA)[11] aids the Council in preparing sustainable policies for the long-term management of flood risk and improving existing emergency planning procedures. The SFRA is used as an evidence base to promote the location of future development primarily in low flood risk areas. This SFRA has been used to inform this FRA.

[8] Lichfield District Council (1998), *Lichfield District Local Plan*.
[9] Lichfield District Council (2012), *Lichfield District Local Plan: Our Strategy*
[10] Lichfield District Council (2008), *Strategic Flood Risk Assessment Level 1, Volume 1.*
[11] Staffordshire County Council (2011), *Staffordshire Preliminary Flood Risk Assessment*. Completed by Royal Haskoning on behalf of Staffordshire County Council.

2.5 Historic sources of flooding

2.5.1 The historic sources of flooding which have occurred either at the location of the route or in close proximity have been determined as part of this FRA. These areas of historic flooding have been identified because places which have flooded in the past may be more susceptible to flooding in the future. Two sources of data relating to historic flooding have been used: local authority information (the relevant SFRA and PFRA) and extents of historic sources of river flooding as provided by the Environment Agency.

2.6 Flood risk approach

River flooding approach

Crossing locations

2.6.1 To determine the river flood risk at locations where the route crosses watercourses and to identify any changes in flood risk as a result of the Proposed Scheme, either existing hydraulic models have been used where available or new hydraulic models have been constructed. Where new models were required flows have been determined in line with current flood estimation guidelines[12].

Flow estimation

2.6.2 The majority of the watercourses that will be crossed by the route within this study area have no known detailed modelling available. Where Flood Zones are associated with these watercourses, the outlines have been determined through the use of broadscale topographic data, which are considered to be a rough guide when determining areas at risk of flooding and hence have not be used for the design of engineering works. There are other watercourses which have no associated Flood Zones. Flows for these watercourses, at the location of the proposed crossing, have been determined for the 1 in 20 (5%), 1 in 100 (1%), 1 in 100 (1%) with a 20% allowance for climate change and 1 in 1000 (0.1%) annual probability events.

2.6.3 A quick estimation of flow was produced at the crossing locations using the Revitalised Flood Hydrograph model (ReFH) where the contributing catchments were represented within the Flood Estimation Handbook (FEH) CD-ROM[13]. A FEH calculation record for the estimation of flow using ReFH is provided in the hydraulic modelling report (Volume 5, WR-004-014).

2.6.4 To estimate flood flows for catchments classed as highly permeable (such as at the Black Brook viaduct), based on catchment descriptors provided in the FEH CD-ROM, the ReFH approach is not considered acceptable. Therefore at these locations, the FEH Statistical method with permeable adjustment, in line with the Environment Agency Flood Estimation Guidelines9 has been undertaken. The associated methodology and FEH pro forma are included in the hydraulic modelling report (Volume 5, WR-004-014).

2.6.5 Small catchments (normally less than approximately 0.5km^2), such as at the Roundhill Wood culvert, are not represented on the FEH CD-ROM and hence it is not possible to

[12] Environment Agency (2012), *Flood estimation guidelines*.
[13] Centre for Ecology and Hydrology (2009), FEH CD-ROM Version 3, ©NERC (CEH).

either produce a catchment boundary or determine catchment descriptors (required for the estimation of flow) from this source. For crossings where the watercourse is not represented within the FEH CD-ROM, a scaling method based on area, in line with the flood estimation guidelines was carried out. Contributing catchment areas at crossing locations were determined using topographic and Ordnance Survey (OS) mapping; in areas of uncertainty slightly larger catchments were defined as a conservative approach. The flows estimated through the use of ReFH for all catchments in the northern study areas in the rural north section of the Proposed Scheme were used to determine a scaling factor. The greatest flow per km^2 was used as a scaling factor for the catchments in this study area which were manually determined. An error allowance of 10% was also applied to reduce the risk of underestimating flows.

Modelling approach

2.6.6 At river crossings where suitable models were not available, such as at all crossings in this study area, new two dimensional (2D) hydraulic models were built utilising the new high resolution Light Detection and Ranging (LiDAR) data collected for the purposes of the Proposed Scheme. Further detail in relation to the hydraulic modelling is included in the hydraulic modelling report, (Volume 5, WR-004-014).

2.6.7 There are several road embankments and raised infrastructures across the watercourses which will potentially provide constriction to flows. The model Digital Terrain Model (DTM) had to be modified to allow for flows through culverts underneath these embankments. In the absence of any survey data of these road embankment culverts, a channel opening of 5m was incorporated at each of these embankments.

2.6.8 The inflow boundaries were mostly applied as steady state flows with unsteady flows applied for certain watercourses. For watercourses with floodplain attenuation such as ponds and lakes or significant obstructions to flow (e.g. due to embankments), the inflows were modelled using unsteady hydrographs. These models were run at longer durations covering the period of the hydrograph and attenuation. The resulting baseline (current) models were run for the 1 in 100 (1%) annual probability with an allowance climate change and 1 in 1000 (0.1%) events over a range of durations depending upon the flow conditions.

2.6.9 The Proposed Scheme models included either viaducts or culverts depending on the scheme design. The railway embankments were represented by modifying the model DTM at those locations. The 1 in 100 (1%) annual probability with an allowance for climate change peak flood levels upstream of the crossings were compared to the baseline (current) levels to assess the change in flood risk. The 1 in 1000 (0.1%) annual probability peak levels were extracted to inform on the vertical alignment of the track.

River flood risk elsewhere along the route

2.6.10 In addition to watercourse crossings, there are sections of the route which are located in areas potentially at risk of river flooding. These have been identified through the use of the Environment Agency Flood Zone mapping. This mapping has been used in preference to SFRA mapping as it is considered more up to date and hence likely to best reflect areas at risk. River flood risk to these sections of the route needs to be

determined both to prevent an unacceptable risk to the Proposed Scheme and to prevent it increasing flood risk as result of a reduction in floodplain storage.

Summary of river flooding approach

2.6.11 Due to the number of river crossings, varying complexities, and the amount of data and information available for each, at some locations the modelling approach is highly specific. These locations have been reported as such and further information is included in the hydraulic modelling report (Volume 5, WR-004-014).

Surface water flood risk

2.6.12 The baseline (current) assessment of surface water flood risk was completed using the Flood Maps for Surface Water (FMfSW). The maps utilised for this assessment are listed as:

- 1 in 30 (3.3%) annual probability and surface water flooding greater than 0.1m deep;
- 1 in 30 (3.3%) annual probability and surface water flooding greater than 0.3m deep;
- 1 in 200 (0.5%) annual probability and surface water flooding greater than 0.1m deep; and
- 1 in 200 (0.5%) annual probability and surface water flooding greater than 0.3m deep.

2.6.13 This mapping identified sections of the route which currently are at specific risk from surface water flooding. The risk classification assigned at each location is dependent on which FMfSW the receptor is located within.

2.6.14 The Proposed Scheme has the potential to interrupt surface water flow which would require mitigation to prevent an increase in flood risk. In addition, other design elements such as landscaping will alter the permeability of the ground and hence modify sections of the surface water catchments. The assessment involved determining the land drainage catchments, surface water runoff from these catchments and the capacity of Sustainable Drainage Systems (SuDS) and culverts.

2.6.15 Land drainage catchments were identified using topographic data (primarily 5m contours, or 1m contours on small or unclear catchments). The assumption was made that linear features such as roads and railways do not act as a cut off for overland flow.

2.6.16 The calculation of Greenfield runoff rates from existing catchments was undertaken using the online SuDS tool[14]. A growth factor of 30% was applied to the 1 in 100 (1%) annual probability rainfall event to determine the flow during this event with an allowance for climate change. A factor of 62% (based on calculations using the Flood Studies Supplementary Report 14[15]) was applied to the 1 in 100 (1%) annual probability rainfall event to determine the flow during the 1 in 1000 (0.1%) annual probability event.

[14] UK Sustainable Drainage Guidance and Tool. HR Wallingford. The Greenfield run-off estimation for sites tool. http://geoservergisweb2.hrwallingford.co.uk/uksd/greenfieldrunoff.aspx. 2013.
[15] Institute of Hydrology (1983), *The Flood Studies Supplementary Report Number 14*.

2.6.17 Run-off from modified sections of the catchment as a result of the Proposed Scheme (e.g. landscape areas) which alter the permeability were determined using the Institute of Hydrology 124[16] (IH124) methodology with a value of 0.5 for the soil parameter and a safety factor of 1.2.

2.6.18 Storage volumes were calculated using the SuDS calculator tool assuming that landscape areas will be impermeable. The storage volumes required were taken to be the sum of the attenuation and long term storage as a conservative approach.

2.6.19 The calculations for the proposed drainage design have been completed in line with the requirements in Volume 1, Section 9.14.

Groundwater flood risk

2.6.20 Groundwater bodies and aquifers present within a 1km buffer of the area of temporary and permanent works have been identified and named on available web-based mapping data for the purposes of the Proposed Scheme.

2.6.21 Field investigations have not yet been undertaken due to limited access to land and the need to integrate investigative requirements from several disciplines.

Sewer systems flood risk

2.6.22 The risk of flooding from the sewer network has also been addressed as part of this assessment. The sewer network data was provided for this assessment by the relevant water companies, Severn Trent Water, to determine locations of the route and other design elements which will be located at areas of risk.

Other sources of flood risk

2.6.23 Reservoir flood risk was assessed using the reservoir inundation maps as shown on the Environment Agency website[17]. The purpose was to identify areas along the route that were at risk of flooding if any reservoirs in the vicinity were to fail.

2.6.24 Canals were identified as another source of potential flood risk, and therefore canals that will be crossed by the Proposed Scheme have been identified in the assessment.

[16] Institute of Hydrology (2004), *Institute of Hydrology, report number 124,* Flood Estimation for Small Catchments.
[17] Reservoir inundation mapping. http://www.environment-agency.gov.uk/homeandleisure/37837.aspx. Accessed September 2013.

3 Design criteria

3.1 Principal design criteria

3.1.1 The Proposed Scheme will provide a safe and reliable high speed rail link which will be compatible with the existing rail network and also HS1.

3.1.2 The railway will only provide a 'passenger' only service. The railway will not provide 'freight' operation.

3.1.3 The design shall seek to ensure that any impacts as a result of its development will be designed out or minimised as far as practicably possible.

3.2 Flood risk design approach statement

3.2.1 The overall project seeks to ensure that there is no increase in flood risk to any existing receptors as a result of the Proposed Scheme. This will be achieved by ensuring that overall flood storage capacity is maintained including an allowance for climate change.

3.2.2 In line with the NPPF technical guidance, increases in peak rainfall intensity and peak river flow of 20%, as a result of climate change, have been allowed for as per the period 2085 to 2115. This 20% increase has been used for the purposes of assessing flood risk. However, the hydraulic modelling involves sensitivity testing which includes a 20% increase, in addition to the 20% allowance for climate change.

3.2.3 All underbridge and viaduct crossings will be designed so that the 1 in 100 (1%) annual probability flow (with allowance for climate change) can pass underneath. Upstream water levels will not be increased and a minimum of 600mm freeboard will be provided to the bridge soffits above this level which will allow for debris should flooding occur. On main rivers, where possible, a freeboard of 1m has been allowed.

3.2.4 Main River underbridges and viaducts will also accommodate river maintenance requirements and allow for a 5.3m vertical clearance above the floodplain ground level.

3.2.5 Culverts will be designed to convey the 1 in 100 (1%) annual probability flow (with allowance for climate change), with a freeboard of 300mm as a minimum applied for the culvert design. The design has also taken into account submerged inverts and the inclusion of mammal ledges.

3.2.6 River crossings will minimise any requirement for replacement floodplain storage areas.

3.2.7 The proposed rail infrastructure will be protected against inundation in the 1 in 1000 (0.1%) annual probability flood event. This will be achieved through ensuring a freeboard of 1m on the 1 in 1000 (0.1%) annual probability flood level. The railway drainage will be designed to have capacity up to the 1 in 100 (1%) annual probability peak rainfall event. However the design will also ensure that the flood level does not exceed 1m below the track level during the 1 in 1000 (0.1%) annual probability rainfall event.

3.2.8 All drainage will be attenuated in order that peak surface water run-off from the proposed infrastructure is no greater than the existing current day baseline run-off under the 1 in 100 (1%) annual probability peak rainfall event.

3.2.9 All drainage will be designed to ensure that disruption to existing groundwater flood flows will be kept to a minimum, both during and following construction of the permanent works.

3.3 Cross drainage design approach statement

3.3.1 The drainage design will ensure that there is no increase in run-off to the receiving watercourse as a result of the railway.

3.3.2 Surface and ground water drainage shall be provided so as to ensure that water levels do not rise to a level closer than 1m below the rail line.

3.3.3 The route will be designed to ensure safe operation of trains during a 1 in 1000 (0.1%) annual probability event.

3.3.4 As part of the drainage design an allowance of 30% has been added to design events for climate change.

4 Data sources

4.1.1 Consistent with the requirements of the NPPF, this assessment considers the risk of flooding from rivers, overland flow (surface water), rising groundwater, overwhelmed drainage and sewer systems, and artificial sources such as reservoirs, lakes and canals.

4.1.2 The route will lie entirely outside the extent of flooding from the sea and therefore the risk of flooding from tidal sources is not considered in this assessment.

4.1.3 The primary datasets for each source of flooding used to assess the design elements are:

- OS 1:10,000 mapping;
- topographic survey commissioned for the purposes of the Proposed Scheme (200mm grid resolution LiDAR survey, in digital terrain model and digital surface model format);
- Environment Agency Flood Zone mapping and historic flood mapping;
- the Environment Agency website for reservoir inundation mapping;
- the Lichfield District SFRA[10];
- the Staffordshire PFRA[11];
- Environment Agency national surface water flood mapping datasets specifically the Midlands FMfSW; and
- Severn Trent Water asset mapping.

4.1.4 A high-level review of the risk of flooding and potential impacts is undertaken on the basis of these datasets across all flood sources. Where this review indicates potentially significant impacts on the risk of flooding, or a risk of flooding to the line, further investigation is undertaken, specifically hydraulic modelling for the areas at risk from river flooding.

5 The Proposed Scheme

5.1 Permanent works

5.1.1 The general design of the Proposed Scheme is described in Volume 2, Section 2.2. The following section describes the main features of the Proposed Scheme in this study area, including the main flood risk mitigation measures.

Start of route at Marl Pit to Oak Dairy Farm

5.1.2 The route enters the study area on embankment continuing from the Curdworth to Middleton area (CFA20). The route continues north on embankment, crossing Gallows Brook. The route crosses the study area boundary three times where it follows the Warwickshire and Staffordshire county boundaries (Map CT-06-116, G6, to Map CT-06-117, H6). Key features of this section will include:

- a 630m long embankment (Trickley Coppice embankment) with a maximum height of 7.5m before the route crosses a minor watercourse (Gallows Brook);
- a 155m long viaduct (Drayton Basset viaduct) over the Gallows Brook floodplain; and
- an embankment with a height of approximately 4.5m.

5.1.3 Landscape earthworks will be provided up to where the railway line crosses Gallows Brook for a second time; raised earthworks will be provided either side of the route north of Gallows Brook culvert. A balancing pond and be provided on the east side of the route, approximately 100m to the south of Oak Dairy Farm.

Oak Dairy Farm to Hints Footpath 9

5.1.4 Continuing to the north, the route enters a cutting with overbridges for Drayton Lane, the A453 Sutton Road and Bangley Lane. This section will be approximately 2.2km long and will include the following key features (maps CT-06-117, H6 to CT-06-118, F6):

- a cutting starting adjacent to Oak Dairy Farm for a length of 2.2km, with a depth of approximately 16.5m.

5.1.5 A balancing pond will be provided on the east side of the route just to the south of Waggoner's Lane. Planting will be provided on both sides of the railway line. Hints Footpath 9 to north of Brockhurst Lane (Rookery Lane).

5.1.6 The route in this section will be approximately 1.3km long. It commences on a low embankment before bearing north and entering a series of side on cuttings into the hills to the east of Hints (Maps CT-06-118, D6 to CT-06-118, B6):

- a 520m embankment beginning just south of the Hints footpath 9 public right of way (PROW), reaching a height of approximately 4.5m; and
- a cutting for a length of 770m with a maximum depth of 15m, commencing at the southern boundary of Roundhill Wood.

5.1.7 Landscaping earthworks with raised earthworks will be provided on both sides of the railway line.

Brockhurst Lane (Rookery Lane) to Black Brook

5.1.8 This section of the route will be approximately 800m long and will include the following key features (Maps CT-06-120, F6 to CT-06-121,E6):

- an embankment 700m long beginning just to the south of Brockhurst Lane, reaching a maximum height of approximately 7m; and
- a viaduct over Black Brook approximately 105m long.

5.1.9 Landscaping earthworks will be provided on the east side of the route and landscape planting will be provided on both sides of the railway line. Two infiltration basins/balancing ponds will be located in the ecological mitigation area west of the proposed route (Job's Hill). One of these ponds will be located north of Brockhurst Lane and the other will be located to the south of Black Brook.

Black Brook to the A51 Tamworth Road

5.1.10 The approximate length of this section of the route is 4km and consists of a short length of embankment then a continuous length of cutting to the study area boundary, and includes the following key features (maps CT-06-121, I5 to CT-06-123, E6):

- a cutting for a length of 3.9km, with a maximum depth of 15m as the railway line approaches Horsley Brook Farm.

5.1.11 The route will leave the area in the north at approximately 5m below ground level.

5.2 Temporary works

5.2.1 All contractors will be required to comply with the environmental management regime for the Proposed Scheme, which will include:

- Code of Construction Practice (CoCP); and
- Local Environmental Management Plans (LEMPs).

5.2.2 The key requirements of the draft CoCP in relation to flood risk are:

- making appropriate use of the Environment Agency's flood warning service;
- site-specific flood risk management plans will be prepared for temporary works at risk of flooding from river, surface water and groundwater sources;
- consider flood risk when planning temporary sites and storing materials;
- obtain consent, as required, for works affecting a watercourse;
- the removal or stopping and sealing of drains and sewers taken out of use;
- no discharge of site run-off to ditches, watercourses, drains or soakaways without agreement of the appropriate authority;
- hoarding and fencing in areas at risk of flooding will be permeable to

floodwater, unless otherwise agreed with the Environment Agency or Local Lead Flood Authority; and

- precautions to be taken to prevent damage to services and to avoid pollution during service diversions, excavations and ground penetration.

5.2.3 The temporary works will include both main and satellite construction compounds. These compounds will be utilised for office accommodation, local storage for plant and materials, car parking, material processing facilities and welfare facilities.

5.2.4 Areas adjacent to these compounds may be used for temporary storage of any topsoil stripped as part of the works.

5.2.5 Temporary worker accommodation will also be required for the Proposed Scheme.

5.2.6 The temporary works that have been assessed are shown on the construction and logistics maps (Volume 5: Map Book – Cross Topic Map CT-05).

6 Existing flood risk

6.1.1 There have been no known incidents of flooding within 1km of the route centre line in this study area identified through the use of the Environment Agency historic flood maps.

6.1.2 The Lichfield SFRA indicates that there has been one recorded incident of localised flooding within 1km of the route within this study area. This event caused inundation 800m east of the route, just east of Oak Farm. The Lichfield SFRA states that this source of flooding is unknown.

6.1.3 The Staffordshire PFRA has also been used to identify potential locations of flooding in the vicinity of the route; however, this mapping does not show any incidents of historical flooding at the location of the route. The PFRA mapping indicates one recorded incident of localised flooding within 1km of the route within this study area. Owing to the location of the event, it is likely to be the same incident as recorded on the Lichfield SFRA.

6.2 River flooding

6.2.1 River flood risk is the risk of flooding posed by rivers and streams. The risk in CFA21 is from Black Brook, two tributaries of Bourne Brook, two tributaries of the River Tame and Gallows Brook. The areas at risk of flooding from this source are shown in Volume 5 Maps WR-05 and WR-06.

6.2.2 The assessment of baseline (current) flood risk involved identifying watercourse crossings and the associated risk through the use of the Flood Zones. The results of this assessment are provided in Table 2. The watercourse identifier references have been taken from Volume 5: Map WR-01-035.

Table 2: Drayton Bassett, Hints and Weeford river flood risk

Watercourse identifier and map reference	Crossing name	Watercourse	1 in 100 (1%) climate change flow	Risk level	Receptor vulnerability
SWC-CFA21-001 (Map WR-01-035, H5)	Gallows Brook culvert	Gallows brook (ordinary watercourse)	0.97m^3/s	Very high	Less vulnerable
SWC-CFA21-002 (Map WR-01-035, G5)	Drayton Bassett viaduct	Ordinary watercourse (tributary of the River Tame)	2.35m^3/s	Very high	Less vulnerable
SWC-CFA21-003 (Map WR-01-035, G5)	Drayton Bassett viaduct	Ordinary watercourse (tributary of the River Tame)	3.27m^3/s	Very high	Less vulnerable
SWC-CFA21-006 (Map WR-01-035, D6)	Hints culvert	Ordinary watercourse (tributary of Bourne Brook)	0.54m^3/s	Very high	Less vulnerable
SWC-CFA21-008 (Map WR-01-035, D6)	Roundhill Wood culvert	Ordinary watercourse (tributary of Bourne Brook)	1.99m^3/s	Very high	Less vulnerable
SWC-CFA21-009 (Map WR-01-035, B5)	Black Brook viaduct	Main River (Black Brook)	9.61m^3/s	Very high	More vulnerable

6.2.3 The Environment Agency Flood Zone mapping indicates two main areas of the Proposed Scheme to be at risk from river flooding in this study area. These are in the

vicinity of Drayton Bassett viaduct and Black Brook viaduct. The Environment Agency flood mapping covers watercourses with catchments greater than 0.5km^2 and hence there are no identified Flood Zones for the culvert crossings including Gallows Brook culvert, Hints culvert and Roundhill Wood culvert. Table 2 shows the map references associated with these areas.

6.2.4 Hydraulic modelling as detailed in Section 2.6 of this report was carried out to provide a more accurate representation of river flood risk along the route, specifically at locations where the route would cross a watercourse. The Drayton Bassett viaduct crosses two watercourses, CFA21-SWC-002 and 003, and hence these watercourses have been assessed in one model and referred to as one crossing. The modelling provided flood extents for the 1 in 100 (1%) annual probability event with a 20% allowance for climate change and for the 1 in 1000 (0.1%) annual probability event. The flood extents and levels as determined through hydraulic modelling are further detailed in the hydraulic modelling report (Volume 5, WR-004-014).

6.2.5 The hydraulic modelling redefines the Flood Zones at the location of the proposed Drayton Bassett viaduct and Black Brook viaduct. Therefore the watercourses crossed by these viaducts are identified to be within Flood Zone 3b (Volume 5: Maps WR-06-059 and 060) and hence classed as at a very high risk in line with Table 1. It was necessary to remodel the flooding extents of this watercourse to provide a more accurate extent of the river flood risk posed to the route.

6.2.6 The hydraulic modelling completed for the proposed culverts in this study area, specifically the Gallows Brook culvert and Hints culvert, indicates that these culverts will be located in areas categorised as being at a very high risk of river flooding.

6.2.7 Hydraulic modelling has not been completed for watercourse SWC-CFA21-008 at the location of Roundhill Wood culvert. This culvert is for the purposes of surface runoff from the Proposed Scheme, rather than for the conveyance of the watercourse at this location, which is already culverted. The design of the Roundhill Wood culvert will be completed in line with the design criteria set out in Section 3 of this report and will prevent an increase in surface water flood risk at this location.

6.2.8 The vulnerability classification provided in Table 2 is based on the NPPF and relates to the vulnerability of existing development at risk of river flooding. In line with the NPPF, a less vulnerable classification has been given to all but one crossing, as shown in Table 2, because the land at risk is utilised for agricultural purposes (land and buildings used for agriculture and forestry). At the Black Brook viaduct residential property is located upstream of the Proposed Scheme and hence a more vulnerable classification has been assigned at this location.

6.2.9 The other locations along the route, not identified in Table 2, are considered to be at a low risk of river flooding.

6.3 Surface water / overland flow

6.3.1 This section is an examination of the existing flood risk posed by rainfall falling on the ground surface, referred to as surface water flooding. It is examined in terms of the water flowing over the ground surface that has not entered a natural drainage channel or artificial drainage system.

6.3.2 The areas at risk from surface water flooding are shown on Volume 5: Maps WR-01-035 and WR-01-036. Table 3 details the risk to the development from this source of flooding.

Table 3: Drayton Bassett, Hints and Weeford sources of surface water flooding

Description of surface water flooding location	Description of possible influence to the Proposed Scheme	Risk
In the vicinity of the Gallows Brook culvert Map WR-01-035, H5	The route will cross areas susceptible to surface water flooding which are associated with Gallows Brook. These areas are primarily categorised as being at a low and medium risk, although small isolated areas are at a high risk of flooding from this source.	High
In the vicinity of the Drayton Bassett viaduct Map WR-01-035, G5	The route crosses areas susceptible to surface water flooding which are associated with the watercourses at this location. These areas are categorised as being at a low and medium risk of surface water flooding.	Medium
Between the southern extent of this study area and Drayton Lane Map WR-01-035, E5	The route will be located to the east of areas susceptible to surface water flooding which are associated with the watercourses t this location. The areas at risk are categorised as being at a low and medium risk of surface water flooding.	Medium
In the vicinity of the Hints culvert Map WR-01-035, D6	The route will cross areas susceptible to surface water flooding which are associated with the watercourse at this location. These areas are categorised as being at a low and medium risk of surface water flooding.	Medium
To the south of Roundhill Wood Map WR-01-035, D6	The route will cross areas susceptible to surface water flooding which are in part associated with watercourse These areas are primarily categorised as being at a low and medium risk, although isolated areas are at a high risk of flooding from this source.	High
Areas to the west of Hints Map WR-01-035, C5	The route will be located in close proximity to large areas at risk from surface water flooding which are associated with watercourses and ponds to the east of the Proposed Scheme at this location. These areas are categorised as being at a low, medium and high risk of surface water flooding. The route also will cross a surface water flow path, which is not associated with a watercourse, at this location.	High
In the vicinity of Black Brook viaduct Map WR-01-035, B5	The route will cross areas susceptible to surface water flooding which are associated with watercourse. These areas are categorised as being at a low, medium and high risk of flooding from this source. The route also will cross a surface water flow path, which is not associated with a watercourse, at this location.	High
The area between the A5 crossing and the Flats Lane crossing Map WR-01-035, F6	The route will cross and will be in close proximity to areas at risk of surface water flooding which are categorised as being at low and medium risk of flooding from this source. At this location the route will cross two areas which are identified as surface water flow routes, not associated with watercourses.	Medium
North of Horsley Brook Farm Map WR-01-036, E6	The route will cross a potential surface water flow path which is not associated with a watercourse. This area is categorised as being at low and medium risk of surface water flooding.	Medium

6.3.3 There are nine locations along the route in this study area which have been identified to be at risk from surface water flooding from the Environment Agency FMfSW. At the majority of these locations the risk of surface water flooding ranges from low to high, however as a conservative approach the highest level of risk has been assigned. Therefore at four locations the risk is considered high and at five locations the risk is considered medium.

6.3.4 In line with the risk category matrix provided in Table 1, and the data available for this FRA, all other locations along the route within this study area are classed to be at no risk from surface water flooding.

6.4 Groundwater

6.4.1 Groundwater flood risk has been qualitatively assessed based on hazard identification and evaluation using the conceptual understanding of the ground conditions at the location of the Proposed Scheme. The assessment of the current groundwater flood risk is based on the presence or otherwise of an aquifer and the relative depth of groundwater level, as well as historic information on the occurrence of groundwater flooding incidents.

6.4.2 The solid geology is predominantly classified as a Secondary B aquifer. Superficial Deposits are classified as Secondary A aquifers, Secondary B aquifers and unproductive strata.

6.4.3 Only very limited data on groundwater levels has been made available within the study area. However, it is considered that groundwater flow is likely to be towards watercourses and groundwater, especially within the alluvium, and that groundwater may be within 2m of ground level.

6.4.4 The SFRA and PFRA do not record any instances of groundwater flooding and therefore the risk is assessed as low.

6.5 Sewer systems

6.5.1 Sewer infrastructure is a potential source of flood risk in the event of a failure. Due to the nature of the closed sewer system, sewer flooding will only be caused if there is a blockage or a leak or if there is a rainfall event greater than the design capacity of the network.

6.5.2 The risk to the route from the sewer network has been determined based on the location of development in relation to the network and the proximity and potential flow paths from inspection covers. Flow paths have been assessed through the use of LiDAR and OS mapping. However, there are no known locations in this study area where the Proposed Scheme will cross or be located in close proximity to the sewer network.

6.6 Artificial sources

6.6.1 Artificial sources of flood risk describe a mechanism whereby flooding would be the result of failure of infrastructure that impounds water such as in a canal or reservoir.

6.6.2 The Proposed Scheme neither crosses nor is in close proximity to any canals in this study area, hence there is no risk from this source of flooding.

6.6.3 The Environment Agency reservoir inundation maps indicate that should Canwell Estate Reservoir fail, flood water would flow in an easterly direction along two watercourses and pose a flood risk to the Proposed Scheme at the Drayton Bassett viaduct (Volume 5: Map WR-01-035, G5). Canwell Estate Reservoir is located in excess of 2km upstream of the Proposed Scheme, specifically the Drayton Bassett viaduct (Volume 5: Map WR-01-035, G5). At this location the extents of flooding shown on the

reservoir inundation maps cover slightly larger extents than the areas at risk from river flooding. However the upstream land use is categorised as less vulnerable and hence if the Proposed Scheme acts as a constriction to flow at this location, no existing vulnerable receptors would be at an increased risk of flooding from this source.

6.6.4 The Environment Agency reservoir inundation maps also indicate that the Proposed Scheme would also be at risk at the location of the Black Brook viaduct (Volume 5: Map WR-01-035, B5) should either Chasewater (Cannock Chase) or Little Aston Pool fail. These reservoirs are located in excess of 10km upstream from the Proposed Scheme and therefore in the unlikely event of reservoir failure the flood water would be at a relatively low velocity which would pose a low hazard to people and property. At the location of the Black Brook viaduct (Volume 5: Map WR-01-035, B5) the extents of flooding shown on the reservoir inundation maps cover slightly larger extents than the areas at risk from river flooding.

6.6.5 Due to the strict regulations and high maintenance associated with reservoirs the risk of breaching is considered unlikely. In line with the risk category matrix in Table 1 the risk of flooding from this source is considered low.

6.7 Summary

6.7.1 The Proposed Scheme will cross six watercourses and therefore it is concluded that the Proposed Scheme will be within areas that are classified as being potentially at a very high risk from river flooding in this study area. The only land uses at risk in this study area (which could be impacted as result of the Proposed Scheme) are classed as less vulnerable, with the exception of one location near the Black Brook viaduct crossing where residential properties are present and hence a more vulnerable classification has been assigned.

6.7.2 There are nine locations along the route which have been identified to be at risk from surface water flooding. The risk at these locations generally ranges from low to high, although as a conservative approach the highest level of risk has been assigned. Therefore four locations have been categorised as being at a high risk and five locations being at a medium risk.

6.7.3 The risk presented by groundwater flooding is considered to be low.

6.7.4 The Proposed Scheme is not considered to be at risk from the sewer network.

6.7.5 There will be no risk to the Proposed Scheme from canal flooding in this study area. Due to the strict monitoring and maintenance requirements, the risk of reservoir flooding to the development in this area is considered low.

7 Flood risk management measures

7.1 River flood risk

Flood risk to proposed scheme

7.1.1 The Proposed Scheme will be raised above floodplain crossings such that the risk of river flooding is less than during the 1 in 1000 (0.1%) annual probability. Therefore the mitigation measures included in the design have ensured that there are no instances where the Proposed Scheme would be at significant risk of river flooding, and consequently no specific mitigation is required.

Impact of proposed scheme

7.1.2 At all floodplain crossings, replacement floodplain storage would be provided upstream of the Proposed Scheme for losses in floodplain storage, including viaduct piers, embankments and all associated development.

Black Brook viaduct

7.1.3 Hydraulic modelling at this location suggests that the Proposed Scheme will result in an afflux of up to 55mm, extending to a maximum distance of 83m upstream of the Black Brook viaduct) during the 1 in 100 (1%) annual probability event with an allowance for climate change. This change in flood level causes a moderate impact. This moderate impact will be reduced through the incorporation of replacement floodplain storage, which is proposed immediately upstream of the viaduct.

Other watercourse crossings

7.1.4 The hydraulic modelling for the other four watercourse crossings in this study area has shown that the Proposed Scheme will have a negligible impact on river flood risk. Therefore any replacement floodplain storage at these locations is likely to provide betterment.

Mitigation for temporary works

7.1.5 The temporary works have the potential to result in an increased river flood risk and be at risk of flooding from this source. The proposed mitigation and measures to prevent an unacceptable risk of river flooding for the temporary works includes signing up to the Environment Agency flood warning system for the "Middle Tame – Low-lying land and roads between Water Orton and Tamworth including the Bourne Brook at Fazeley" and also "Bourne Brook (Tamworth) – Low lying-land and roads between Shenstone and Fazeley". Any temporary crossings will be designed to prevent an increased flood risk through ensuring sufficient capacity during the 1 in 100 (1%) annual probability event; an indication of the flows which will be considered are included in Table 2.

7.2 Surface water flood risk

Flood risk to Proposed Scheme

7.2.1 In this study area, the areas categorised as being at a high risk of surface water flooding are generally associated with the watercourses identified in the river flooding sections in this report. At these locations the scheme design will ensure that the track

is situated above the 1 in 1000 (0.1%) annual probability event flood level with a 1m freeboard. Therefore as long as there is no blockage of these structures, a low surface water flood risk to the track is anticipated at these locations.

7.2.2 At the other four locations where the route potentially crosses surface water flow paths, the track will either be raised on an embankment and/or the track drainage system will direct surface water flow away from the Proposed Scheme. Therefore, as long as the collection systems and surface water culverts are designed with sufficient capacity, there should be no backing up, and no expected risk of flooding to the Proposed Scheme.

Impact of Proposed Scheme

7.2.3 Potential increases in peak discharge rates of surface water run-off will be attenuated prior to discharging to the receiving watercourse. Any additional surface water to be discharged will be at a trickle rate to prevent exceeding the current capacity of the receiving watercourse.

7.3 Risk of flooding from groundwater

Flood risk to Proposed Scheme

7.3.1 The risk from groundwater flooding to the Proposed Scheme has been assessed as low and therefore no specific management measures are considered necessary.

Impact of the Proposed Scheme

7.3.2 The Proposed Scheme is no anticipated to have an impact on groundwater flooding and therefore no specific management is considered necessary.

7.4 Risk of flooding from drainage systems

7.4.1 There will be no risk of flooding from drainage systems to the Proposed Scheme, and there will be no anticipated effects on the risks of flooding from drainage systems within the study area arising from the Proposed Scheme. Therefore, no specific mitigation would be required.

7.5 Risk of flooding from artificial sources

Flood risk to Proposed Scheme

7.5.1 There are no instances where the Proposed Scheme would be at significant risk of flooding from artificial sources, and consequently no specific mitigation is required.

Impact of the Proposed Scheme

7.5.2 Although the Proposed Scheme is at risk of flooding resulting from the complete failure of Canwell Estate, Chasewater (Cannock Chase) or Little Aston Pool reservoirs, the replacement floodplain storage provided to mitigate the potential effects of the Drayton Bassett viaduct and Black Brook viaduct would serve to either fully or partially offset any potential effects of the Proposed Scheme on flooding from this source. Due to the low probability of such flooding occurring, and the likely low significance of any impacts arising from the Proposed Scheme, it is not considered practical to provide additional mitigation for this scenario.

8 Post development flood risk assessment

8.1 River flooding

8.1.1 The key design elements of the proposed route with potential flood risk considerations have been modelled for this FRA. The modelling methodology and results specific for each watercourse crossing are included in the modelling report (Volume5, WR-004-014). A summary of the results are presented in Table 4. The watercourse identifier references have been taken from Volume 5: Map Book – Water Resources, Maps WR-01-035 and WR-01-036.

Table 4: Drayton Bassett, Hints and Weeford river flood risk

Watercourse identifier and map reference	Crossing name	1 in 100 (1%) climate change flow	Change in flood level 1 in 100 (1%) climate change	Change in flood level 1 in 1000 (0.1%)	Proposed Scheme 1 in 1000 (0.1%) level	Length of impacted upstream reach[18]
SWC-CFA21-001 (Map WR-05-059, J6)	Gallows Brook culvert	0.97m^3/s	0mm	-12mm	78.807m AOD	0m
SWC-CFA21-002 (Map WR-05-059, H6)	Drayton Bassett viaduct	2.35m^3/s	0mm	0mm	85.810m AOD	0m
SWC-CFA21-003 (Map WR-05-059, H6)	Drayton Bassett viaduct	3.27m^3/s	0mm	0mm	85.810m AOD	0m
SWC-CFA21-006 (Map WR-05-060, I5)	Hints culvert	0.54m^3/s	0mm	-1mm	91.751m AOD	0m
SWC-CFA21-009 (Map WR-05-060, D6)	Black Brook viaduct	9.61m^3/s	55mm	74mm	79.976m AOD	83m

8.1.2 The hydraulic modelling completed for this study area shows that the Proposed Scheme at four of the five watercourses identified in Table 3 would have a negligible impact on flood levels during the 1 in 100 (1%) with an allowance for climate change and the 1 in 1000 (0.1%) annual probability flood events.

8.1.3 The results for watercourses CFA21-SWC-002 and 003 are the same because these were included within the same model as the route crosses these watercourses with one structure, the Drayton Bassett viaduct.

8.1.4 At the Black Brook viaduct, the hydraulic modelling has shown that the Proposed Scheme would have a moderate impact on flood levels during both the 1 in 100 (1%) and the 1 in 1000 (0.1%) annual probability flood events. However, further hydraulic modelling has shown that the proposed replacement floodplain storage area which will be located immediately upstream from the crossing will reduce the change on flood levels to a minor impact.

8.1.5 There are no significant diversions of watercourses in this study area. Minor diversions and straightening will be required for the culverts under the Proposed Scheme

[18] Length of reach upstream of the Proposed Scheme along which flood levels during the 1 in 100 (1%) annual probability+ CC are greater than 10mm.

however this realignment is not considered to have a significant impact on river flood risk and hence has not been modelled.

8.1.6 Watercourses pose a river flood risk to the other design elements in this study area. The areas at risk from river flooding are shown on Volume 5: Maps WR-05-059 to WR-05-061 and WR-06-059 to WR-06-061 which are based on the hydraulic modelling results rather than Environment Agency Flood Zone mapping. The river flood risks to these works are included in Table 5.

Table 5: River flood risks to the other design elements

Works at Risk	Watercourse identifier and map reference	Location Description	Description of the works and flood risk	Risk
Landscaping Earthworks	SWC-CFA21-001 (Map WR-05-059, J6)	Gallows Brook culvert	Various landscaping and earthworks will be located adjacent to the northern and southern banks of Gallows Brook.	High
Landscaping Earthworks Highways Other	SWC-CFA21-003 (Map WR-05-059, H6)	Drayton Bassett viaduct and northwards along the watercourse at this location.	Proposed landscaping and earthworks will be located in areas adjacent to this watercourse. The diversion of Shirrall Drive requires this watercourse to be culverted. Main utility works will also be required in the northern area at this location.	Very high
Landscaping Earthworks Other	SWC-CFA21-006 (Map WR-05-060, I5)	Hints culvert	Proposed landscaping, earthworks and a PROW diversion will be located in close proximity to this watercourse. Main utility works will also be required at this location.	High
Landscaping Earthworks	SWC-CFA21-008 (Map WR-01-035, D6)	Roundhill Wood culvert	Proposed landscaping, earthworks and a PROW diversion will be located in close proximity to this watercourse.	High
Landscaping Earthworks	SWC-CFA21-009 (Map WR-01-035, B5)	Black Brook viaduct	Proposed landscaping, ecological planting and earthworks will be located within and on the extents of the areas at risk of flooding.	High

8.1.7 The proposed diversion of Shirrall Drive will require the watercourse (SWC-CFA21-003) to be culverted at a new location. However this watercourse is currently culverted under the existing Shirrall Drive, which will be stopped and removed. The new culvert will be upstream of the existing one and therefore under the assumption that the new culvert has the same capacity as existing, it will not result in an increased constriction on flows at this location. The land uses in this area are categorised as less vulnerable and therefore even if flood risk is increased, which is not expected, no existing vulnerable receptors would be at an increased risk of flooding.

8.1.8 Temporary works as required for the construction phase are also located in areas at risk from river flooding. The areas at risk from river flooding are shown on maps WR-05 and WR-06 and are based on the hydraulic modelling results rather than Environment Agency Flood Zone mapping. The temporary works at risk are listed in Table 6.

Table 6: River flood risk to temporary works

Watercourse identifier and map reference	Receptor	Comment	Risk
SWC-CFA21-001 (Map WR-05-059, J6)	Gallows Brook culvert	A temporary plant crossing and a site access/haul road will be required in the areas at risk of flooding from these watercourses.	Very high
SWC-CFA21-002 and SWC-CFA21-003 (Map WR-05-059, H6)	Drayton Bassett viaduct	A temporary plant crossing, a site access/haul road and temporary fencing will be required in the areas at risk of flooding from these watercourses. These areas at risk will be in the area at risk during the 1 in 20 (5%) annual probability event.	Very high
SWC-CFA21-006 (Map WR-05-060, I5)	Hints culvert	Rookery Lane Underpass compound will be located adjacent to the watercourse at this location in an area categorised as being at a medium risk. Temporary fencing will also cross this area at risk and will be located in areas at very high risk of flooding.	Very high
SWC-CFA21-009 (Map WR-01-035, B5)	Black Brook viaduct	A temporary plant crossing, a site access/haul road and temporary fencing will be required in the area at risk of flooding from this watercourse. The area at risk will be in the area at risk during the 1 in 20 (5%) annual probability event.	Very high

8.1.9 There are four locations of temporary works that are located in areas at risk from river flooding. The areas at risk have been identified through the hydraulic modelling completed for this assessment.

8.1.10 Hydraulic modelling is not considered necessary for the temporary works because the works will be constructed in line with the CoCP and thus the design will consider river flood risk. Therefore temporary works will not result in an increased flood risk to any existing receptors.

8.1.11 The hoarding and fencing around a site for security purposes has the potential to alter flow paths and thus impact on flood risk at the two locations identified in Table 6. However the draft CoCP states that hoarding and fencing in areas at risk of flooding will be permeable to floodwater, unless otherwise discussed with the Environment Agency or Local Lead Flood Authority. This will ensure that the floodplain continues to function effectively for storage and conveyance of floodwater.

8.1.12 The temporary works other than those outlined in Table 6 are considered to be at a low risk of river flooding.

8.2 Surface water / overland flow

8.2.1 The proposed track will result in increased run-off rates due to a reduction in infiltration capacity. Therefore the entire length of the track may be at risk from this source and could increase risk elsewhere.

8.2.2 In addition the track drainage has the potential to increase flood risk in receiving watercourses if not attenuated. In this study area there are seven proposed balancing ponds, these are located as follows:

- to the north of the Drayton Bassett viaduct;
- to the south of the Waggoner's lane;
- to the north of Brockhurst Lane underbridge;

- two either side of Black Brook viaduct; and
- two either side of the A51 Tamworth Road overbridge.

8.2.3 The outfall from these balancing ponds will be attenuated to ensure that runoff rates are not increased above existing levels to prevent an increase in risk.

8.2.4 The route has the potential to interrupt surface water movement, which could result in an increase in surface water flood risk. The Environment Agency FMfSW indicates overland flow paths.

8.2.5 Two overland flow paths, which are not associated with watercourses, are identified to discharge into the Black Brook (SWC-CFA21-009) and could be impacted as a result of the Proposed Scheme. One of these flow routes is located to the south of Job's Hill and flows in an easterly direction towards the Proposed Scheme. The proposed drainage network at this location will collect this surface water and direct it under the route via the Milditch Wood culvert downstream of which it will be discharged to Black Brook. Therefore even though the Proposed Scheme will alter the overland flow path of surface water at this location, it will discharge in a similar location as at present.

8.2.6 An overland flow path, not associated with a watercourse, flows in a southerly direction and discharges to the Black Brook at the location of the proposed Black Brook viaduct. As a result of the Proposed Scheme, this surface water will enter the proposed balancing pond at this location prior to being discharged to the Black Brook. Therefore at this location the Proposed Scheme would not have a significant impact on overland flow paths.

8.2.7 To the north of the A5 crossing overland flow paths are evident and may be crossed by the Proposed Scheme. However at this location track drainage channels are proposed on both sides of the route and hence any surface water flowing towards the Proposed Scheme at this location would be collected in these drainage channels.

8.2.8 In the vicinity of the Flat's Lane crossing, an overland flow path, not associated with a watercourse, will be crossed by the Proposed Scheme. At this location water flows in a westerly direction and will be collected in the proposed track drainage channels prior to being directed across the track via the Flats Lane Siphon.

8.2.9 The potential impact of the Proposed Scheme on surface water movement, not identified as above, will be incorporated within the scheme design. Therefore the works will have no impact on surface water flood risk.

8.2.10 There are various aspects of the other design elements which will be at risk from surface water flooding. The surface flood risks to the other design elements, as identified from the Environment Agency FMfSW are included in Table 7.

Table 7: Surface water flood risks to other design elements of the Proposed Scheme

Works at Risk	Location Description and map reference	Description of possible influence to the Proposed Scheme	Risk
Landscaping	Gallows Brook culvert (Map WR-01-035, H5)	Various landscaping works will be located adjacent to the northern and southern banks of Gallows Brook. These areas at risk are categorised as being at low and medium risk of surface water flooding.	Medium
Landscaping Earthworks Highways Other	Drayton Bassett viaduct and northwards to Shirrall Drive (Map WR-01-035, G5)	Proposed landscaping, earthworks and the realignment of Shirrall Drive will be located in areas susceptible to surface water flooding. Mains utility works will also be required in the northern area at this location. The areas at risk from surface water flooding in this location are categorised as being at low and medium risk.	Medium
Landscaping Earthworks Other	Hints culvert (Map WR-01-035, D6)	Proposed landscaping, earthworks, a PROW diversion and mains utility works will be required at this location. The area susceptible to surface water flooding is categorised as being at a low and medium risk.	Medium
Landscaping Earthworks Other	Roundhill Wood culvert (Map WR-01-035, D6)	Proposed landscaping, earthworks and a PROW diversion will be located in this location. The area susceptible to surface water flooding is categorised as being at a low, medium and high risk.	High
Landscaping Earthworks Highways	In the vicinity of the Black Brook viaduct and southwards to Rookery Lane (Map WR-01-035, B5)	Proposed landscaping, ecological planting, earthworks, an underbridge and a culvert will be located within areas categorised as being at low and medium risk of surface water flooding.	Medium
Landscaping Earthworks	To the north of the A5 crossing (Map WR-01-036, F6)	Proposed landscaping and earthworks will be located in areas categorised as being at a low and medium risk of surface water flooding.	Medium
Landscaping Earthworks Highways	In the vicinity of Flat's lane crossing (Map WR-01-036, E6)	Proposed landscaping, earthworks and the Flat's Lane diversion will be located in areas categorised as being at a low and medium risk of surface water flooding.	Medium
Landscaping Earthworks	North of Horsley Brook Farm (Map WR-01-036, B6)	Proposed landscaping and earthworks will be located in isolated areas categorised as being at a low and medium risk of surface water flooding.	Medium

8.2.11 There are eight locations where other design elements are located in areas susceptible to surface water flooding. In general these areas range from low to high risk and as a conservative approach the highest level of risk has been assigned. Therefore, one of the eight locations are categorised as being at a high risk and seven being at a medium risk of surface water flooding.

8.2.12 The other design elements not listed in Table 7 are considered to be at no risk from surface water flooding in line with the flood risk category matrix.

8.2.13 All other design elements, including those additional to Table 7, have the potential to increase surface water runoff rates through reduced infiltration capacity. The design for the Proposed Scheme includes surface water runoff management (such as drainage channels and balancing ponds) to prevent an increased risk of flooding from this source both on site and in neighbouring areas.

8.2.14 Table 8 details the risk to the temporary design elements from surface water flooding.

Table 8: Sources of surface water flooding to temporary works

Description of surface water flooding location and map reference	Description of possible influence on temporary design elements	Risk
Gallows Brook culvert (Map WR-01-035, H5)	A temporary plant crossing and a site access/haul will be located in areas categorised as being at low and medium risk of surface water flooding.	Medium
Drayton Bassett viaduct and northwards to Shirrall Drive (Map WR-01-035, G5)	A temporary plant crossing, a site access/haul and temporary fencing will be located in areas that are categorised as being at low and medium risk of surface water flooding.	Medium
Hints culvert (Map WR-01-035, D6)	A temporary plant crossing, a site access/haul and temporary fencing will be located in areas that are categorised as being at low and medium risk of surface water flooding.	Medium
Roundhill Wood culvert (Map WR-01-035, D6)	A temporary plant crossing and a site access/haul will be located in areas categorised as being at low, medium and high risk of surface water flooding.	High
Black Brook viaduct (Map WR-01-035, B5)	A temporary plant crossing, a site access/haul and temporary fencing will be located in areas which are categorised as being at low, medium and high risk of surface water flooding.	High
To the north of the A5 crossing (Map WR-01-036, F6)	A site access/haul and temporary fencing will be located in areas categorised as being at low and medium risk of surface water flooding.	Medium
In the vicinity of Flat's lane crossing (Map WR-01-036, E6)	A site access/haul will be located in areas categorised as being at low and medium risk of surface water flooding.	Medium

8.2.15 There are seven locations of temporary design elements in this study area which have been identified to be at risk from surface water flooding from the Environment Agency FMfSW. A conservative approach has been taken in categorising risk as outlined earlier in this section. Therefore, in line with the flood risk category matrix (Table 1) a high risk of surface water flooding has been categorised at two locations and a medium risk at five locations.

8.2.16 Construction compounds have the potential to interrupt surface water flow paths. However there are no construction compounds in this study area that will interrupt surface water flow paths which are identified on the Environment Agency FMfSW.

8.2.17 In line with the risk category matrix provided in Table 1, all other locations for temporary works within this study area are classed to be at no risk from surface water flooding.

8.2.18 The works will be completed in line with the draft CoCP and hence the design of the temporary works will prevent an unacceptable level of surface water flood risk on site.

8.2.19 Temporary works not identified to be at risk on the FMfSW also have the potential to increase flood risk from this source in neighbouring areas as a result of reduced ground permeability. Therefore, in line with the CoCP, surface water will be managed at all locations of temporary works, including areas not identified to be at risk from surface water in Table 8. This will ensure that the temporary works are at an acceptable level of risk and do not cause an increased risk elsewhere from surface water flooding.

8.3 Groundwater

8.3.1 Developments may increase the risk of groundwater flooding where a barrier to groundwater flow in constructed across the natural flow path. The presence of such a barrier may impede groundwater flow causing levels to increase up gradient; if these levels rise to the ground surface groundwater flooding may occur.

8.3.2 A review of the Proposed Scheme in this CFA does not indicate that any barriers to flow will be introduced that will affect a significant aquifer thickness.

8.3.3 It is therefore concluded that the scheme will not increase the risk of groundwater flooding.

8.4 Sewer systems

8.4.1 The Proposed Scheme has been identified to be not at risk of flooding from the sewer network. Therefore no associated mitigation would be required.

8.5 Artificial sources

8.5.1 At locations where the route crosses canals or areas at risk of flooding as a result of reservoir failure, there is potential that the Proposed Scheme may either increase risk from this source, or divert flood water causing new areas to be put at risk.

Reservoirs

8.5.2 The Environment Agency reservoir inundation maps indicate that should Canwell Estate Reservoir fail, flood water would flow in an easterly direction along two watercourses (SWC-CFA21-002 and 003) and pose a flood risk to the Proposed Scheme at the Drayton Bassett viaduct. The other design elements located in this area at risk are a balancing pond, landscaping and earthworks. The temporary works identified within the reservoir inundation extent in this area are Drayton Bassett viaduct compound, temporary site access/haul road and temporary construction fencing.

8.5.3 Canwell Estate Reservoir is located in excess of 2km upstream of the Proposed Scheme, specifically the Drayton Bassett viaduct. At this location the extents of flooding shown on the reservoir inundation maps cover slightly larger extents than the areas at risk from river flooding. However the upstream land use is categorised as less vulnerable and hence if the Proposed Scheme (specifically the earthworks) acts as a constriction to flow at this location, no existing vulnerable receptors would be at an increased risk of flooding from this source.

8.5.4 The Environment Agency reservoir inundation maps also indicated that the Proposed Scheme would also be at risk at the location of the Black Brook viaduct should either Chasewater (Cannock Chase) or Little Aston Pool fail. The other design elements located in this area at risk are a balancing pond, an access road, maintenance and emergency access points and earthworks. The temporary works identified within the reservoir inundation extent in this area are a temporary site access/haul road, a plant crossing via a temporary culvert or bridge, a worksite for plant and materials and temporary construction fencing.

8.5.5 Chasewater (Cannock Chase) or Little Aston Pool reservoirs are located in excess of 10km upstream of the Proposed Scheme and therefore in the unlikely event of reservoir failure the flood water would be at a relatively low velocity which would pose a low hazard to people and property. At the location of the Drayton Bassett viaduct the extents of flooding shown on the reservoir inundation maps cover slightly larger extents than the areas at risk from river flooding. The majority of upstream land use is categorised as less vulnerable, however there are two residential properties in the area at risk of flooding, as shown on the reservoir inundation maps, which would be classed as more vulnerable. However flood water following failure of either Chasewater (Cannock Chase) or Little Aston Pool would have to flow for over 10km, and through numerous constrictions including the under the M6, A38 and Dog Lane upstream of the Proposed Scheme. It is assumed that these bridges will provide a greater constriction on flow than the proposed Drayton Bassett viaduct, based on structure width, and thus flood water will not be further constricted (causing increased flood levels) at the location of this proposed viaduct. Therefore it is concluded that the Proposed Scheme will not result in a significant increase in flooding, as a result of reservoir failure, at this location.

8.5.6 There are no other locations within this study area that are at risk of flooding from reservoir failure as shown on the Environment Agency reservoir inundation maps. It is therefore concluded that the Proposed Scheme, including the route, other design elements and temporary works, will be at a low risk of flooding from this source (Table 1) and will not result in an increased risk elsewhere.

Canals

8.5.7 There are no canals within this CFA.

8.6 Summary

8.6.1 The Proposed Scheme, including the route, other design elements and the temporary works will be located in areas at a very high risk of flooding from rivers. The design will ensure that the track is located above the 1 in 1000 (0.1%) annual probability flood event, with a freeboard, and hence will be at an acceptable level of risk. The other design elements and temporary works will be completed in line with the CoCP requirements and hence will also be at an acceptable level of risk. The hydraulic modelling completed for this assessment has shown that the Proposed Scheme will have a moderate impact on flood risk. However the design will include mitigation to reduce this to a negligible impact.

8.6.2 All elements of the Proposed Scheme will cross many areas susceptible to surface water flooding. In general, at each of the areas the risk ranges from low to high, although as a conservative approach the highest level of risk has been assigned resulting in many of the areas being categorised as being at a high risk from surface water flooding. However the Proposed Scheme will mitigate surface water run-off to ensure that the works are at an acceptable level of flood risk and do not result in an increased risk elsewhere.

8.6.3 The Proposed Scheme involves development within area at a low risk from groundwater flooding.

8.6.4 The Proposed Scheme does not involve development in areas at risk of flooding from the sewer network.

8.6.5 There are no canals crossed or located in close proximity to the temporary design elements. Due to the strict monitoring and maintenance requirements, the risk of reservoir flooding to the development is considered low. The design ensures that the Proposed Scheme does not result in an increased risk from this source both to the development and elsewhere.

9 Conclusions

9.1.1 The Proposed Scheme, including the route, other design elements and the temporary works, are to be located within areas at risk from flooding from a range of sources. However the temporary works will be designed to and will follow the CoCP such that development will be at an acceptable level of risk and will not cause an increased risk elsewhere. The proposed mitigation as part of the permanent works will also ensure that the Proposed Scheme will be at an acceptable level of flood risk and will not result in an increased risk elsewhere.

9.1.2 The magnitude of impact and significance of effects have been based on the EIA Scope and Methodology Report (SMR), see Volume 5: Appendix CT-001-000/1. Table 9 shows a summary of the sources of flood risk within this study area and the associated magnitude of impact and significance of effects.

9.1.3 In terms of river flooding, the magnitude of impact in this study area of the Proposed Scheme with the floodplain replacement storage is negligible and significance of effects neutral.

9.1.4 Although there are areas of the Proposed Scheme at no, low, medium and high risk from surface water flooding, overall the risk from this source is categorised as high, as a conservative approach. However the overall magnitude of impact is negligible and the significance is neutral. This has been determined because the design of the permanent works will be in line with the design criteria outlined in Section 14 of this report and the temporary and construction works assessed as part of this FRA are in line with the draft CoCP.

9.1.5 Groundwater flood risk has been assessed as low within the CFA.

9.1.6 No risk from the sewer network has been identified in this CFA.

9.1.7 There are no canals in this study area and hence no associated flood risk from this source. The risk of reservoir flooding is considered low in this study area resulting in a low significance of effect.

Table 9: Summary of Flood Risk Receptors showing the overall magnitude of impact and significance of effects

Flood risk receptor	Risk category	Magnitude of impact	Significance of effects
Areas at risk from river flooding	Very High	Negligible	Neutral
Areas at risk from surface water flooding	High	Negligible	Neutral
Areas at risk from groundwater flooding	Low	Negligible	Neutral
Areas at risk from drainage and sewer flooding	No risk	Negligible	Neutral
Areas at risk of flooding from artificial sources	Low	Negligible	Neutral

9.2 Residual flood risk to the Proposed Scheme

9.2.1 Residual flood risks arise in situations that are not included in standard design scenarios, for example when a culvert becomes blocked causing flooding upstream. All design is generally undertaken assuming that existing infrastructure is functioning

under normal conditions. Consequently, there may be areas where the potential severity of flooding may exceed the design standard under certain circumstances.

Residual flood risks from river sources

Drayton Bassett viaduct

9.2.2 There is one existing hydraulic structure in the vicinity of the Drayton Bassett viaduct. This structure is the existing Shirrell Drive culvert, located upstream of the Drayton Bassett viaduct, which will be replaced with a new structure following the realignment of this road. Depending on the constriction on flow caused by the new Shirrell Driver culvert, any failure of the structure could potentially cause a minor increase in flood levels at the location of the Proposed Scheme.

Black Brook viaduct

9.2.3 There is one existing hydraulic structure in the vicinity of the Black Brook viaduct. This structure is an existing access track crossing, located upstream of the proposed viaduct. Depending on the constriction on flow caused by this existing crossing, any failure of the structure could potentially cause a minor increase in flood levels at the location of the Proposed Scheme.

Culverts

9.2.4 At the location of the proposed culverts in this study area, there are no significant hydraulic structures within the vicinity of the Proposed Scheme that would create additional residual risks to the Proposed Scheme.

Residual flood risks from surface water sources and minor watercourses

9.2.5 All culverts within the Proposed Scheme are designed with a minimum internal headroom of 300mm above the design flood water level to minimise the risk of blockage. Therefore, there are not expected to be any significant increases in risk of flooding at dry valley crossings arising from potential blockage of culverts

Residual flood risks from groundwater

9.2.6 Groundwater levels rise and fall relatively slowly, and therefore any change in the risk of flooding from this source would be the result of below ground intervention. The risk of groundwater flooding already considered in this FRA presents an absolute risk, and there are no significant residual risks arising from this source.

Residual flood risks from the sewer network

9.2.7 Blockage of underground sewer networks can cause surcharge and associated flooding. At any locations where the existing sewer infrastructure will need diverting, any replacement infrastructure would be to at least the same standard as existing. Consequently, no additional residual risk to the Proposed Scheme would be expected as a result of drainage system failure.

Residual flood risks from artificial and surface sources

9.2.8 This assessment considers the potential for total failure of Canwell Estate, Chasewater (Cannock Chase) or Little Aston Pool reservoirs, which is deemed to be the most extreme case of flooding from these sources. Therefore it is considered that there are no further residual risks from artificial sources of flood risk.

9.3 Residual effects of the Proposed Scheme on flood risk

9.3.1 All culverts within the Proposed Scheme will be designed to convey the 1 in 100 year (1% annual probability) flow including an allowance for climate change with a minimum internal headroom of 300mm above the design flood water level (to minimise the risk of blockage). Consequently, there would be negligible increase in upstream residual flood risks arising from the introduction of culverts within the Proposed Scheme.

9.3.2 All viaducts within the Proposed Scheme will also be designed to convey the 1 in 100 (1%) annual probability flow with an allowance for climate change. As a minimum the design will ensure a 600mm freeboard will be provided to the bridge soffits above this level, and on main rivers where possible, a freeboard of 1m will be allowed. These freeboards will allow for debris and hence prevent a significant increased in residual risk in upstream areas as a result of the Proposed Scheme.

10 References

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